

DEPARTMENT OF COMMERCE

CIRCULAR
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BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 81

**BIBLIOGRAPHY OF SCIENTIFIC LITERATURE
RELATING TO HELIUM**

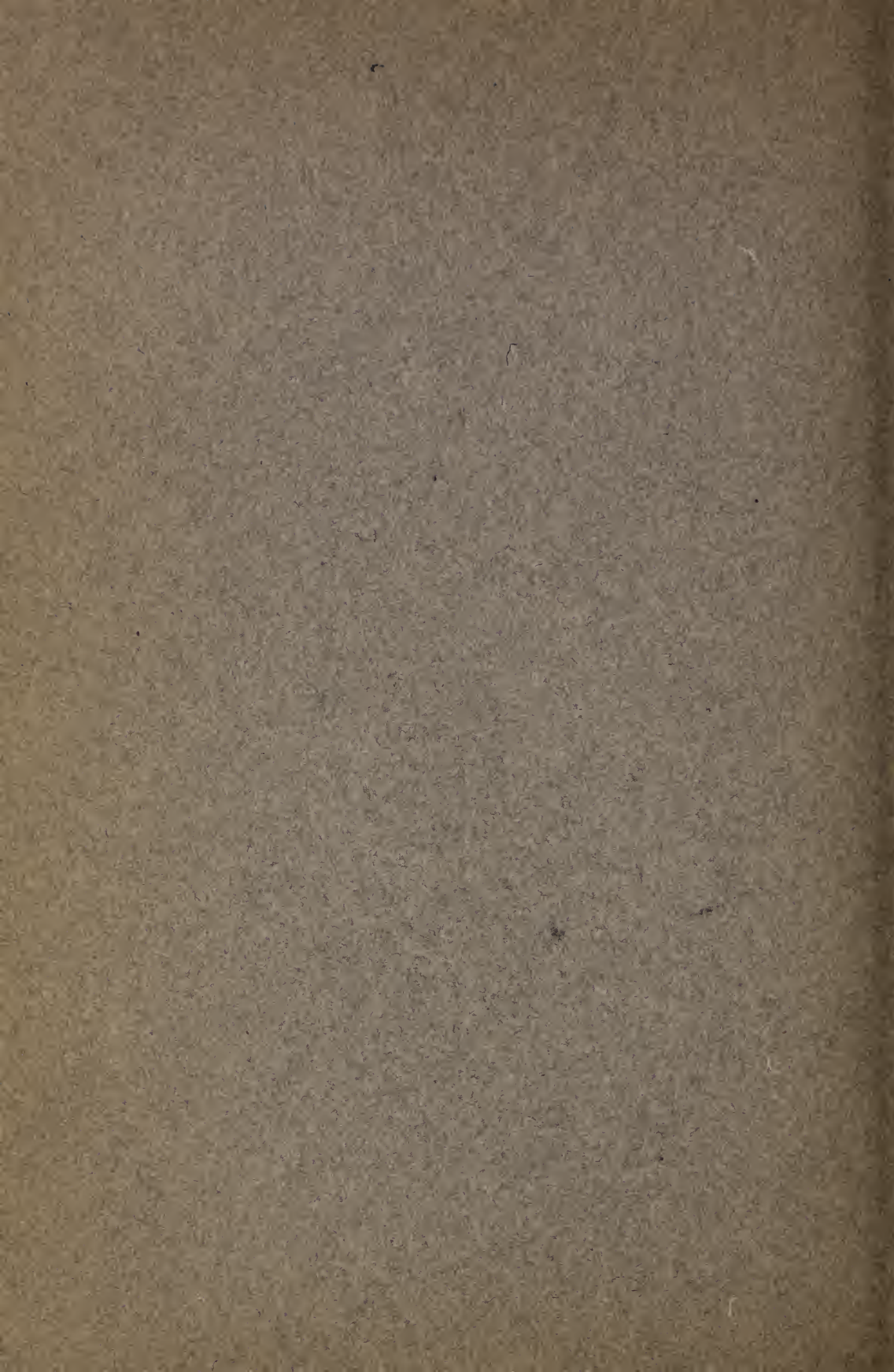
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¹ Prepared by E. R. Weaver, Bureau of Standards, Washington, D. C.

I. INTRODUCTION

It is particularly appropriate at this time to issue a bibliography of the scientific literature relating to helium. The development, during the war, of great fractionating plants capable of separating from natural gas a sufficient quantity of helium to supply a fleet of airships has aroused the keen interest, not only of engineers and scientists, but also of the general public in the unique properties of this gas.

The year 1918 certainly marks the beginning of a new era in the history and use of helium. Before that time only a few liters of the gas had ever been collected, and the cost per liter was enormous. The separation of millions of liters of the gas at a very moderate cost, therefore, makes the gas at once available for many purposes which formerly seemed impossible of accomplishment.

Helium has probably been the most interesting of all the elements to the theoretical scientist on account of the romantic history of its discovery, its occurrence in a remarkable condition of solid solution in many minerals, its formation as a product of the disintegration of the radioactive elements, its liquefaction after a decade of unsuccessful attempts by some of the world's greatest experimenters, the attainment by its use of temperatures below those at which the resistances of pure metals vanish, its many unique physical properties, and the many important theoretical conclusions which have been drawn from its behavior.

All of these points of interest have been the subjects of very thorough investigation. The important developments of the future will probably be along the line of the applications of helium, many of which have already been suggested; but in order to make the most of these possible applications it is necessary to know the properties on which they are based. It is as a guide to these properties that, it is hoped, this bibliography will find its chief usefulness.

This bibliography was first prepared at the beginning of the development of helium for balloon-gas purposes and was intended as an aid in that enterprise. It has since been brought up to date, and is believed to contain practically everything published up to January 1, 1919, except reviews and other articles containing no original work which were published in inaccessible foreign journals and contained no material which was not available in English or American publications. Such articles have been purposely omitted.

II. ARRANGEMENT OF TITLES

The arrangement of material under each subhead has, in general, been such that closely related articles occur together in their chronological order. The bibliography is thus, in effect, a brief outline history of the subject. An exception to this arrangement is made in the case of articles on the occurrence of helium, which have been arranged alphabetically according to the authors' names. This was done because the papers by different authors are usually but slightly related to each other, and the chronological development seems of less importance than the bringing together of the papers, often numerous, of each author.

III. DISCOVERY AND IDENTIFICATION

1. DISCOVERY

- JANSSEN. *Compt. rend.*, **67**, p. 838; 1868: Discovery of new spectrum lines in sun, since found to belong to helium.
- FRANKLAND and LOCKYER. *Proc. Roy. Soc., Lond.*, **17**, p. 91; 1868: Announce the existence of an element in the sun unknown on earth and name it helium.
- PALMIERI. *Gazz. Chim. Ital.*, **12**, p. 556; 1882: Discovery of helium spectrum in rocks from Vesuvius.
- NASINI and ANDERLINI. *Atti. Accad. Lincei. Roma.* (5), **13**, I, p. 368; 1904: Recognition of helium in Vesuvius lavas confirming the discovery of Palmieri.
- HILLEBRAND, W. F. *Am. J. Sci.* (3), **40**, p. 384; 1890: Observed the presence in uraninite of gases since found to be helium and nitrogen. Condensed form of following reference.
- HILLEBRAND. *Bull. U. S. Geol. Survey*, No. 78, p. 43; 1890: Chemical and spectroscopic tests of gases obtained from uraninite led to conclusion that gas was nitrogen.
- HILLEBRAND. *Am. Jour. Sci.* (3), **42**, p. 390; 1891: New analyses of uraninite.
- RAMSAY. *Proc. Roy. Soc. (Lond.)*, **58**, pp. 65, 81; 1895: Reports partial identification of helium spectrum in gas from cleveite.
- LOCKYER. *Proc. Roy. Soc. (Lond.)*, **58**, p. 67; 1895: Partial confirmation of Ramsay's identification of helium.
- RAMSAY. *Chem. News*, **71**, p. 151; 1895: Discovery of helium in cleveite.
- CROOKES. *Chem. News*, **71**, p. 151; 1895: Measured the wave lengths of the spectrum lines of the gas isolated from cleveite by Ramsay and identified the gas as helium.
- RUNGE and PASCHEN. *Chem. Ztg.*, **19**, p. 997; 1895: Observed double lines in spectrum of helium from minerals and cast doubt upon identity of mineral and solar helium.
- HUGGINS, W. *Chem. News*, **71**, p. 283; 1895: Differences in spectra of helium from minerals and in the sun.
- HUGGINS, W. *Chem. News*, **72**, p. 27; 1895: Observed double helium lines in solar spectrum.
- RUNGE and PASCHEN. *Math. natw. Mitt. Berlin*, p. 323; 1895: Identity of spectra of solar and mineral helium.
- WILDE. *Phil. Mag.* (5), **40**, p. 466; 1895: Identity of spectra of solar and mineral helium.
- LOCKYER. *Proc. Roy. Soc., Lond.*, **62**, p. 52; 1897: Existence of helium in fixed stars and nebulae.
- RAMSAY. *Ann. Chim. Phys.* (7), **13**, p. 433; 1898: Discovery of helium.
- RAMSAY, W. *The Gases of the Atmosphere, the History of their Discovery.* Book, London, Macmillan & Co. *Chem. Abs.*, **10**, p. 313; 1916.

2. ELEMENTARY NATURE OF HELIUM

BRAUNER, B. Chem. News, **71**, p. 271; 1895.

BRAUNER, B. Chem. News, **74**, p. 223; 1896.

HILL, E. A. Am. J. Sci. (3), **50**, 359; 1895.

RAYLEIGH. Chem. News, **74**, p. 260; 1896.

IV. OCCURRENCE OF HELIUM¹

1. IN MINERALS

[See also formation from radioactive substances.]

ADAMS, E. P. Am. J. Sci. (4), **19**, p. 321; 1905; Helium in carnotite.

BORDAS, F. Compt. rend., **146**, pp. 628-630, 1908; Chem. Abs., **2**, p. 1926; Search for small quantities of helium in minerals.

BORDAS. Compt. rend., **146** pp. 896-898; 1908; Chem. Abs., **2**, p. 2043; Helium in minerals containing uranium.

BROGGER, W. C. Pharmacia, **1**, pp. 49-53, 65-70; 1904: Ores of uranium containing helium and radium.

CLEVE. Compt. rend., **120**, p. 834, 1895; Chem. News, **71**, p. 201, 1895; Occurrence of helium in cleveite.

COLLIE, J. N., and TRAVERS, M. W. J. Chem. Soc., **67**, p. 684; 1895: Helium a constituent of certain minerals.

DEBIERNE, A. Ann. phys. (9), **2**, pp. 478-488; 1904: Preparation of helium from fluorspar crystals. Contains also an account of unsuccessful efforts to obtain helium from other sources.

KITCHIN, E. S., and WINTERSON, W. G. J. Chem. Soc., **89**, pp. 1568-1575; 1906: Malacone, a silicate of zirconium containing helium.

KOHLSCHUTTER, V. Ann. Chem., **317**, pp. 158-189; 1901: Helium in uranium minerals.

KOHLSCHUTTER and VOGDT. Ber., **38**, pp. 1419-1430, 2992-3002; 1905: Helium in uranium minerals.

LANGHE, H. Z. naturw., **82**, pp. 1-34, 1910; Chem. Abs., **4**, p. 2920: Studien über die Zusammensetzung heliumführender Mineralien. (Studies on the structure of helium-bearing minerals.)

LANGLET. Z. anorg. Chem., **10**, p. 289; 1895: Helium in cleveite.

LOCKYER. Compt. rend., **120**, p. 1103, 1895; Chem. News, **72**, p. 283, 1895: Occurrence of helium in minerals.

MAGLI, G. Rend. soc. chim. ital. (2), **5**, pp. 420-423, 1914; Chem. Abs., **9**, p. 1005: Helium in titanite. Occurs in amounts proportional to the radioactivity of the mineral.

MOISSAN and DESLANDERS. Compt. rend., **126**, p. 1689; 1898: Helium in cerite.

MOSS. Trans. Roy. Dublin Soc. (2), **8**, p. 153; 1904: Removal of helium from minerals by evacuation. Can obtain only a little over 1 per cent of total by this method.

VON OEFELE, F. Pharm. Zentralhalle, **57**, pp. 83-84, 1916; J. Chem. Soc., **110**, II, p. 284, 1916; Chem. Abs., **10**, p. 2654, 1916: Helium in samarskite and its relation to other elements present.

PIUTTI, A. Radium, **7**, pp. 146-149, 1910; Chem. Abs., **4**, p. 3055: Nonradioactive minerals containing helium.

PIUTTI. Radium, **7**, pp. 178-179, 1910; Chem. Abs., **5**, p. 247: Helium in recent minerals.

¹ The material under this heading is arranged alphabetically according to authors' names because of the general slight relation between papers by different authors.

- PIUTTI. *Nature*, **84**, pp. 543-544, 1910; *Chem. Abs.*, **5**, p. 626: The absorption of helium in salts and minerals. A hypothetical explanation of the accumulation of helium in certain minerals.
- PIUTTI. *Radium*, **8**, pp. 204-205, 1911; *Chem. Abs.*, **6**, p. 1255: The presence of helium in autinite and the period of life of ionium.
- PIUTTI. *Radium*, **10**, pp. 165-168, 1913; *Chem. Abs.*, **7**, p. 3076: Helium in glucinum minerals.
- PIUTTI. *Atti. Acad. Lincei*, **22**, pp. 140-144, 1913; *Chem. Abs.*, **7**, p. 2352: Helium and beryllium minerals.
- RAMSAY, *Compt. rend.*, **120**, p. 1049, 1895; *Ann. Chim. Phys.* (7), **13**, p. 433, 1898: Helium in meteorites.
- RAMSAY and TRAVERS. *Proc. Roy. Soc., Lond.*, **60**, p. 442; 1896: Occurrence of helium in minerals.
- STRUTT, R. J. *Nature*, **75**, p. 271, 1907; *Chem. Abs.*, **1**, p. 817: Helium and argon in common rocks.
- STRUTT. *Nature*, **75**, p. 390; 1907: An occurrence of helium in the absence of radioactivity.
- STRUTT. *Proc. Roy. Soc., Lond. (A)*, **76**, pp. 80-101; 1908: Helium and argon in rocks.
- STRUTT. *Proc. Roy. Soc., Lond. (A)*, **80**, pp. 56-57, 1908; *Chem. Abs.*, **2**, p. 944; *Radium*, **5**, pp. 202-211, 1908: The association of helium and thorium in minerals.
- STRUTT. *Proc. Roy. Soc., Lond. (A)*, **80**, pp. 572-594, 1908; *Chem. Abs.*, **3**, p. 2651: Helium and radioactivity in minerals.
- STRUTT. *Proc. Roy. Soc., Lond. (A)*, **81**, pp. 278-279, 1908; *Chem. Abs.*, **3**, p. 2651: Helium in saline minerals and its probable connection with potassium.
- STRUTT, R. J. *Proc. Roy. Soc. Lond. (A)*, **81**, pp. 272-277, 1908; *Chem. Abs.*, **3**, p. 615: The accumulation of helium in geological time.
- STRUTT. *Chem. News*, **99**, pp. 145-146, 1909; *Chem. Abs.*, **3**, p. 2531: The leakage of helium from radioactive minerals.
- STRUTT. *Proc. Roy. Soc. Lond. (A)*, **83**, pp. 96-99, 1910; *Proc. Roy. Soc., Lond. (A)*, **83**, pp. 298-301; *Chem. Abs.*, **4**, p. 1146; *Chem. Abs.*, **4**, p. 1424: The accumulation of helium in geological time.
- STRUTT. *Proc. Roy. Soc., Lond. (A)*, **84**, pp. 194-196, 1910; *Chem. Abs.*, **5**, p. 28: The accumulation of helium in geological time.
- STRUTT. *Nature*, **85**, p. 6, 1911; *Chem. Abs.*, **5**, p. 626: Helium and geological time. An answer to Piutti's hypothesis of absorption to account for the presence of helium in rocks.
- THOMSON, J. *Zeit. phys. Chem.*, **25**, p. 112, 1898: Occurrence of helium in minerals. Chiefly calcium fluoride.
- TRAVERS. *Nature*, **71**, p. 248, 1905: Helium occurs in radioactive minerals in form of supersaturated solid solution.
- TSCHERNIK, J. *Russ. Phys. Chem. Soc.*, **29**, p. 291, 1899: Helium in cerium-bearing minerals from the Caucasus.
- VALENTINER, S. *Kali*, **6**, pp. 1-3; *Chem. Abs.*, **8**, p. 480; *Neues Jahrb. Min. Geol.*, 1913, I Ref., p. 195: Helium content of blue rock salt.
- WHERRY, E. T. *Am. Mineral*, **2**, pp. 105-108, 1917; *Chem. Abs.*, **11**, p. 2570: The occurrence of the native elements. (Including helium.)
- WILDE, H. *Phil. Mag.* (5), **40**, p. 466, 1895: The occurrence of helium in cleveite.

2. OCCURRENCE IN MINERAL WATERS

- BOUCHARD and TROOST. *Compt. rend.*, **121**, p. 392, 1895: Helium in a spring at Cauterets in the Pyrenees.
- CZAKO, E., and LAUTENSCHLAGER. *Chem. News*, **108**, p. 16, 1913; *Chem. Ztg.*, **37**, p. 936, 1913; *Chem. Abs.*, **7**, 3450: Helium content of gases from Hot Spring, at Wildbad, in the Black Forest. Gases contained 0.71 per cent helium.
- EWERS. *Physik. Zeit.*, **7**, p. 224, 1906: Helium and argon in hot springs.
- HERRMANN, A., and PESENDORFER, F. *Physik. Zeit.*, **6**, pp. 70-71, 1905: Radioactivity of the gases evolved from the Karlsbad springs.
- KAYSER, H. *Chem. News*, **72**, p. 223, 1895; *Chem. Ztg.*, **19**, p. 1549, 1895: Helium in the gases from springs at Wildbad, in the Black Forest.
- MOUREU, C. *Compt. rend.*, **121**, p. 819, 1895: Helium in spring water at Maizieres.
- MOUREU. *Compt. rend.*, **135**, p. 1335, 1902: Helium in the spring Vieille Quelle, in the Pyrenees.
- MOUREU. *Compt. rend.*, **139**, pp. 852-855, 1904: The chemical composition of the mixture of radioactive gases liberated from the waters of certain hot springs.
- MOUREU. *Compt. rend.*, **142**, p. 1155, 1906.
- MOUREU and BIGNARD. *Compt. rend.*, **143**, pp. 795-797, 1906: Helium in certain springs. Gas from one of the springs contained 5.34 per cent helium.
- MOUREU and BIGNARD. *Compt. rend.*, **146**, pp. 435-437, 1908: Recent researches on the rare gases from hot springs.
- MOUREU. *Bull. Soc. Chim. (4)*, **9**, pp. 1-25, 1911; *Rev. gen. sci.* **49**, pp. 65-76, 1911: Investigations on the rare gases from hot springs.
- NASINI, R. *Atti. Accad. Lincei. Roma (5)*, **13**, I, pp. 217, 367, 1904: Helium in certain Italian springs.
- PESENDORFER, F. *Chem. Ztg.*, **29**, p. 359, 1905: Helium in the Karlsbad springs.
- PRYTZ and THORKESSON. *Kgl. Danske. Vidensk. Selsk. Forh.*, p. 317, 1905: The occurrence of helium in warm island springs.
- RAYLEIGH. *Chem. News*, **72**, p. 223; 1895: Helium in gases from the springs at Bath.
- SIEVEKING and LAUTENSCHLAGER. *Physik. Zeit.*, **13**, pp. 1043-1051, 1912; *Chem. Abs.*, **7**, 1841; *Ber. physik. Ges.*, **14**, p. 910, 1913: Helium in hot springs and natural gases. No direct relation between radioactivity and helium content was found.
- TROOST and OUVARD. *Compt. rend.*, **121**, p. 798, 1895: Helium in spring water at Cauterets.

3. OCCURRENCE IN NATURAL GAS

- CADY, H. P., and MCFARLAND, D. F. *Trans. Kan. Acad. Sci.*, **26**, Part II, p. 802, 1907; *Sci.*, **24**, p. 344, 1906; *Chem. Abs.*, **1**, p. 1528: Helium in Kansas natural gas. Some samples contained as much as 2 per cent. Geological zones of approximately equal helium content were located.
- CADY, H. P., and MCFARLAND, D. F. *J. Am. Chem. Soc.*, **29**, pp. 1524-1536, 1907; *Chem. Abs.*, **2**, p. 386: The occurrence of helium in natural gas and the composition of natural gas. Helium is found in practically all natural gas in amounts which increase, in general, with increasing nitrogen and decreasing hydrocarbon content.
- CZAKO, E. *Zeit. Anorg. Chem.*, **82**, pp. 249-277, 1913; *Chem. Abs.*, **7**, p. 3450: The helium content and radioactivity of natural gases. The production of helium discharged yearly from two of the wells examined would require the disintegration of 165,000 and 28,000 tons of Ra, respectively.
- ERDMANN, E. *Ber.*, **43**, pp. 777-782, 1910; *Chem. Abs.*, **4**, p. 1957: Helium-containing gases of the German potash beds.
- MOUREU, C., and LEPAPE, A. *Compt. rend.*, **155**, pp. 197-200, 1912; *Chem. Abs.*, **6**, p. 3075: Some natural gaseous mixtures particularly rich in helium. Discusses gases from eight French sources.

- MOUREAU, C., and LEPAPE, A. *Compt. rend.*, **158**, pp. 598-603, 1913; *Chem. Abs.*, **8**, 1699: Helium from fire damp and the radioactivity of coal. Helium evolved from one mine is equal to 12 cu. m. per day. Radioactivity of gas and coal does not account for it.
- SEIBEL, C. W. Paper read before meeting of the Am. Chem. Soc., Apr. 10-14, 1917; *Abs. in Met. Chem. Eng.*, May, 1917: Helium and associated elements in Kansas natural gas.
- VOLLER, A., and WALTER, B. *Hamburger Wiss. Inst.*, **28**, 1910; *Chem. Abs.*, **5**, p. 3510; *Petroleum*, **6**, p. 1062: Helium and argon in the natural gas of Neuen-gamme. Contained 0.01-0.02 per cent helium.

4. OCCURRENCE IN AIR

- RAYLEIGH and RAMSAY. *Proc. Roy. Soc., Lond.*, **59**, p. 198, 1896; *Proc. Roy. Soc. Lond.*, **60**, p. 206, 1896: Helium in the air. Negative results.
- TRAVERS. *Proc. Roy. Soc., Lond.*, **60**, p. 449, 1896: Separation of helium from the air.
- KAYSER, H. *Chem. Ztg.*, **19**, p. 1549, 1895: Helium in the air.
- FRIEDLANDER. *Z. Physik. Chem.*, **19**, p. 657, 1896: Helium in the air. Estimated to be one part per billion.
- CROOKES, W. *Chem. News*, **78**, p. 198, 1898: Helium in the air.
- RAMSAY and TRAVERS. *Proc. Roy. Soc., Lond.*, **67**, p. 329, 1900: Helium in the air. Isolated by fractionation.
- DEWAR, J. *Proc. Roy. Soc., Lond.*, **68**, pp. 360-366, 1901; *Proc. Roy. Soc. Lond.*, **74**, 127, 1904: Separation of helium from the air.
- RAMSAY. *Proc. Roy. Soc., Lond.*, **76** (A), p. 111, 1905: Amount of helium in the air. One part in 245,300 by volume.
- BORDAS, F., and TOUPLAIN. *Compt. rend.*, **147**, pp. 591-594, 1908: Helium in the air.
- NASINI, ANDERLINI, and SALVADORI. *Mem. Accad. Lincei* (5), **5**, pp. 25-82, 1905: Gases from Vesuvius and Campo Flegrei.
- PIUTTI, A. *Radium*, **7**, pp. 142-146, 1910; *Chem. Abs.*, **5**, p. 247: Helium in the air of Naples and Vesuvius.

V. FORMATION OF HELIUM

1. FROM RADIOACTIVE SUBSTANCES

- RAMSAY and SODDY. *Proc. Roy. Soc., Lond.*, **72**, p. 204, 1903; *Zeit. Phys. Chem.*, **47**, pp. 490-494, 1904; *Physik Zeit.*, **4**, p. 229, 1903: The production of helium by radium.
- RAMSAY and SODDY. *Proc. Roy. Soc., Lond.*, **73**, pp. 346-358, 1904; *Zeit. Phys. Chem.*, **48**, pp. 682-696, 1904; *Physik. Zeit.*, **5**, pp. 349-356, 1904: Experiments on the production of helium from radium.
- STARK, J. *Natur. Rundschau*, **18**, pp. 429-430, 1903: The formation of helium from radium.
- STARK, J. Separate publication 1903: Dissozierung und umwandlung chemischer atome. (The dissociation and transformation of chemical atoms.)
- DEWAR and CURIE. *Compt. rend.*, **138**, p. 190, 1904; *Chem. News*, **89**, p. 85, 1904: Formation of helium from radium.
- HIMSTEDT and MEYER. *Ann. Phys.* (4), **15**, p. 184, 1904: Formation of helium from radium.
- JNDRIKSON. *Physik. Zeit.*, **5**, p. 214, 1904: Formation of helium from radium.
- SCHENK. *Sitz.-Ber. Akad. Berlin*, **37**, 1904: Formation of helium from radium.
- RUTHERFORD. *Phil. Mag.* (6), **10**, p. 290, 1905; *Arch. sc. phys. nat.*, **19**, pp. 31, 125, 1905: Formation of helium from radium.

- DEBIERNE. *Compt. rend.*, **141**, p. 383, 1905: Helium from radium salts and actinium.
- GIESEL, F. *Ber.*, **38**, p. 2299, 1905: Proof of formation of helium from radium bromide.
- FREUND, M. *Jahr. physik. Ver.* 1904-1905, pp. 38-39, 1906: The transformation of radium into helium.
- CROOKES. *Chem. News*, **94**, p. 144, 1906: The production of helium from radium.
- DEWAR, J. *Proc. Roy. Soc. Lond.*, **81**, pp. 280-286, 1908; *Chem. News*, **98**, pp. 188-190; *Chem. Abs.*, **3**, pp. 281, 616: The rate of production of helium from radium.
- DEWAR, J. *Proc. Roy. Soc., Lond.*, **83**, p. 404, 1910; *Chem. Abs.*, **4**, p. 2410: Long-period determination of the rate of production of helium from radium. Found 0.463 cu. mm. per gram per day.
- RUTHERFORD, E., and BOLTWOOD, B. B. *Proc. Manch. Lit. Phil. Soc.*, (6), **54**, 1910; *Chem. Abs.*, **4**, p. 1266: Production of helium by radium.
- BOLTWOOD and RUTHERFORD. *Phil. Mag.*, **22**, pp. 586-604, 1911; *Chem. Abs.*, **6**, p. 26: Production of helium from radium. Find rate of 156 cu. mm. per year per gram of radium.
- KAUFFMANN, H. *Zeit. angew. Chem.*, **17**, p. 1393, 1904: Formation of helium from radium emanation.
- HEMSTEDT and MEYER. *Ann. Physik.* (4), **17**, pp. 1005-1008, 1905: Formation of helium from radium emanation.
- HEMSTEDT and MEYER. *Ber. natf. Ges.*, **16**, pp. 10-12, 1906: Formation of helium from radium emanation.
- BRUNER, L., and BEKIER, E. *Physik Z.*, **15**, pp. 240-241, 1914; *Chem. Abs.*, **8**, p. 1700: Attempt to reverse the reaction $\text{RaEm} = \text{RaA} + \text{He}$ ion by means of an electric discharge in helium gas.
- MARCKWALD, W. *Physik. Z.*, **15**, pp. 440-441, 1914; *Chem. Abs.*, **8**, p. 2845: Experiments on the decomposition of radium emanation in a helium atmosphere. No indication that disintegration of radium emanation can be retarded was found.
- RAMSAY, W. *Z. angew. chem.*, **24**, pp. 1304-1307, 1908; *Chem. Abs.*, **2**, p. 2645: The radioactive gases and their relation to the noble gases of the atmosphere.
- RAMSAY, W. *Arch. Sci. phys. nat.*, **9**, pp. 237-262, 1909: The inert gases of the atmosphere and their derivation from the emanations of the radioactive substances.
- GIESEL, F. *Ber.*, **40**, p. 3011-3017, 1907; *Chem. Abs.*, **2**, 755: The first decomposition products of actinium and the formation of helium from actinium.
- BOLTWOOD, B. B. *Proc. Roy. Soc., Lond. (A)*, **85**, pp. 77-81, 1910; *Chem. Abs.*, **5**, p. 3539: Report on the separation of ionium and actinium from certain residues and on the production of helium by ionium.
- SODDY, F. *Nature*, **79**, p. 129; *Radium*, **5**, pp. 361-362, 1908: Production of helium from uranium.
- SODDY. *Umschau*, **13**, pp. 375-377, 1907: Production of helium from uranium and thorium.
- STRUTT, R. J. *Nature*, **81**, p. 158, 1909; *Chem. Abs.*, **4**, p. 412: Rate of helium production from the complete series of uranium products. Finds 10.4×10^{-8} cu. cm. per year per gram of U_3O_8 .
- STRUTT, R. J. *Proc. Roy. Soc., Lond. (A)*, **84**, pp. 379-388, 1910; *Chem. Abs.*, **5**, p. 627. Measurements of the rate of production of helium in thorianite and pitchblende.
- SODDY. *Phil. Mag.*, **16**, pp. 513-30, 1908; *Chem. Abs.*, **3**, p. 281: Attempts to detect the production of helium from the primary radio elements. One result gave 2×10^{-12} gram helium per year per gram of thorium.
- RUTHERFORD, E. *Trans. Roy. Soc., Lond. (A)*, **204**, pp. 169-217, 1904: The succession of changes in radioactive bodies.

- MEYER, G. *Zeit. Electrochem.*, **13**, pp. 375-377, 1907; Evolution of helium from radioactive substances.
- BOLTWOOD, B. B. *Am. J. Sci.* (4), **23**, pp. 77-78, 1907; *Physik. Zeits.*, **8**, pp. 97-141, 1907; The ultimate disintegration products of the radioactive elements.
- DEBIERNE, A. *Ann. Phys.* (9), **2**, pp. 428-488, 1914; *Chem. Abs.*, **9**, p. 1428: Review of experiments on the production of helium by radioactive substances.

2. SUPPOSED FORMATION OF HELIUM FROM NONRADIOACTIVE SUBSTANCES

- RAMSAY, W. *J. Chem. Soc.*, **103**, pp. 264-266, 1913; *Chem. Abs.*, **7**, p. 1441: The presence of helium in the gas from the interior of an X-ray bulb.
- COLLIE, J. N., and PATTERSON, H. *Nature*, **90**, pp. 653-654, 1913; *Chem. Abs.*, **7**, p. 1441: Origin of helium and neon in vacuum tubes.
- THOMSON, J. J. *Nature*, **90**, pp. 645-647, 1913; *Chem. Abs.*, **7**, p. 1441; *Science*, **37**, pp. 360-364; *Mon., Sci.* (5), **3**, pp. 628-629, 1913: The appearance of helium and neon in vacuum tubes. Explained as liberation from substances not radioactive unless aided by bombardment by cathode rays.
- STRUTT, R. J. *Proc. Roy. Soc., Lond. (A)*, **89**, pp. 499-506, 1914; *Chem. Abs.*, **8**, p. 1236: Unsuccessful attempts to observe the production of neon or helium by electric discharge.
- COLLIE, PATTERSON, and MASSON. *Proc. Roy. Soc., Lond. (A)*, **91**, pp. 30-45, 1915; *Chem. Abs.*, **9**, p. 20: The production of helium and neon by the electric discharge. Argument to prove production.
- DEBIERNE, A. *Ann. phys.* (9), **2**, pp. 478-488, 1914; *Chem. Abs.*, **10**, p. 2325: Experiments on the production of helium. All efforts to produce it by chemical reactions were unsuccessful.

VI. SEPARATION AND PURIFICATION OF HELIUM

- LANGLET. *Z. anorg. Chem.*, **10**, p. 289, 1895: Preparation of helium from cleveite.
- TRAVERS. *Proc. Roy. Soc., Lond.*, **60**, p. 449, 1896: Separation of helium from air.
- RAMSAY, W., and TRAVERS, W. *Proc. Roy. Soc., Lond.*, **67**, pp. 329-333, 1901: Isolation of helium from the air and its physical constants.
- TRAVERS, M. W., and JAQUEROD, A. *Z. Physik. Chem.*, **45**, pp. 451-455, 1903: Note on the preparation of helium.
- DEWAR. *Proc. Roy. Soc., Lond.*, **74**, p. 127, 1904: Separation of helium from air.
- DEWAR, J. German Patent No. 169514, 1905: Preparation of helium from air by absorption of other gases in wood charcoal at a low temperature.
- EWERS, P. *Ann. Phys.* (4), **17**, p. 781, 1905: Preparation and purification of helium.
- LA SOCIÉTÉ L'AIR LIQUIDE. British Patent No. 22316 of 1908: Liquefaction and rectification process for separating helium and neon from the air.
- JAQUEROD, A., and PERROT, F. J. *Compt. rend.*, **144**, p. 135, 1907; *Chem. Abs.*, **1**, p. 963: Preparation of pure helium by filtering the gas from cleveite through a quartz partition.
- GRAY, J. A. *Proc. Roy. Soc., Lond. (A)*, **82**, pp. 301-306, 1909; *Chem. Abs.*, **3**, p. 1740: Liberation of helium from minerals by grinding.
- WOOD, D. O. *Proc. Roy. Soc., Lond. (A)*, **84**, pp. 70-78, 1910; *Chem. Abs.*, **4**, p. 2082: The liberation of helium from minerals by the action of heat.
- SKAUPY, F. *Verh. deut. physik Ges.*, **18**, pp. 230-232, 1916; *J. Chem. Sec.*, **110**, II, p. 469, 1916; *Chem. Abs.*, **10**, p. 3022: The separation of gas mixtures under the influence of the direct current. Helium and argon, among other gases, may be separated in a cathode tube.
- SIEVERTS, A., and BRANDT, R. *Z. angew. Chem.*, **27**, I, p. 424, 1914, and **29**, I, pp. 402-404, 1916; *Chem. Abs.*, **11**, p. 1058: Apparatus for the determination of the noble gases.

VII. PROPERTIES OF HELIUM

1. ELECTRICAL AND MAGNETIC PROPERTIES

[See also spectrum.]

- STRUTT. *Phil. Mag.* (5), **49**, p. 293, 1900: Electrical discharges in argon and helium.
- RITTER. *Ann. Phys.* (4), **14**, p. 118, 1904: The sparkling potential in helium.
- SODDY and MCKENZIE. *Proc. Roy. Soc. (A)*, **80**, pp. 92-109, 1908; *Jahrb. Radioakt.*, **5**, pp. 14-17, 1908: The electric discharge in monatomic gases.
- WATSON, H. E. *Proc. Cam. Phil. Soc.*, **17**, pp. 90-107, 1912; *Chem. Abs.*, **8**, p. 289: Experiments on the electric discharge in helium and neon.
- DEFREGGER, R. *Ann. Physik.* (4), **12**, pp. 662-665, 1903: The cathode drop in helium.
- FRANCK and POHL. *Verh. deut. phys. Ges.*, **9**, pp. 194-199, 1907; *Chem. Abs.*, **2**, 505: The mobility of the helium ion.
- GILL, E. W., and PIDDUCK, F. B. *Phil. Mag.*, **16**, pp. 280-290, 1908; *Chem. Abs.*, **3**, p. 21: Ionization by collision in argon and helium.
- GILL, E. W., and PIDDUCK, F. E. *Phil. Mag.* **23**, pp. 837-849, 1912; *Chem. Abs.*, **6**, 2030: Ionization by collision in helium.
- NUTTING, P. G. *Bull. Bur. Stds.*, **8**, pp. 487-494, 1912; *Chem. Abs.*, **7**, p. 1140: Luminous properties of conducting helium gas.
- DORN, E. *Physik. Zeit.*, **8**, pp. 589-590, 1907; *Chem. Abs.*, **2**, p. 227: Canal rays in hydrogen, helium, and argon.
- KOENIGSBERGER and KUTSCHEWSKI. *Chem. Ztg.*, **35**, p. 616, 1911; *Chem. Abs.*, **6**, p. 2711: The behavior of helium canal rays.
- ROBINSON, J. *Physik. Zeit.*, **11**, pp. 11-13, 1910; *Chem. Abs.*, **4**, p. 863: Absorption of cathode rays by helium.
- BAZZONI, C. B. *Phil. Mag.*, **32**, pp. 566-575, 1916; *Chem. Abs.*, **11**, p. 903: Ionization potential of helium. The experimental determination does not agree with Bohr's theory.
- BOUTY, E. *Compt. rend.*, **145**, p. 225, 1907; *Chem. Abs.*, **1**, p. 2853: The dielectric cohesion of helium.
- HOCHHEIM, E. *Verh. deut. physik. Ges.*, **10**, pp. 446-448, 1908; *Chem. Abs.*, **2**, p. 3175: Determination of the dielectric constant of helium.
- HOCHHEIM, E. *Dissertation* (Marburg, 1909): The dielectric constant of helium.
- SKAUPY, F. *Verh. deut. physik. Ges.*, **18**, pp. 230-232, 1916; *Chem. Abs.*, **10**, p. 3022; *J. Chem. Soc.*, **110**, II, p. 469: The separation of gas mixtures under the influence of the direct current.
- TANZLER, P. *Ann. Physik.*, **24**, pp. 931-938; *Chem. Abs.*, **2**, p. 2180, 1908: The magnetic behavior of air, argon, and helium as compared with oxygen.

2. SPECTRUM OF HELIUM

[See also electric properties and theoretical discussions under Miscellaneous.]

- CROOKES and LOCKYER. *Compt. rend.*, **120**, p. 1103, 1895.
- CROOKES. *Chem. News*, **71**, p. 151, 1895; *Chem. News*, **72**, p. 87, 1895.
- PALMER, DEFOREST. *Sill. Am. J. Sci.* (3), **50**, p. 357, 1895.
- LOCKYER and CROOKES. *Chem. News*, **72**, p. 87, 1895.
- RAMSAY, COLLIE, and TRAVERS. *J. Chem. Soc.*, **67**, p. 684, 1895.
- RUNGE and PASCHEN. *Chem. Ztg.*, **19**, p. 997, 1895; *Math. naturw. Mitt. Berlin*, 1895, pp. 323, 377.
- SCHUSTER. *Chem. News*, **72**, p. 224, 1895.
- WILDE, H. *Phil. Mag.* (5), **40**, p. 466, 1895.
- TRAVERS. *Proc. Roy. Soc., Lond.*, **60**, p. 449, 1896.
- RAMSAY. *Ann. Chim. Phys.* (7), **13**, p. 465, 1898.

- RAMSAY and TRAVERS. *Zeit. phys. chem.*, **26**, p. 135, 1898.
- LIVEING, G. D., and DEWAR, J. *Ann. Chim. phys.*, **22**, pp. 482-493, 1901.
- GRAY, STEWART, HOUSTOUN, and MCQUISTAN. *Proc. Roy. Soc., Lond.*, **72**, p. 16, 1903.
- LOCKYER and BAXANDALL. *Proc. Roy. Soc., Lond.*, **74**, p. 546, 1905.
- GIESEL, F. *Ber.*, **39**, p. 2244, 1906: The spectrum of helium from radium bromide.
- SODDY, F. *Proc. Roy. Soc., Lond. (A)*, **78**, p. 429, 1907: The spectroscopic recognition of very small amounts of helium.
- STARK, J. *Verh. deut. physik. Ges.*, **16**, pp. 468-474, 1914; *Chem. Abs.*, **8**, p. 3264: Note on the arc and spark spectrum of helium.
- MERRILL, P. W. *Bur. Standards, Sci. Paper*, p. 302, 1917; *Chem. Abs.*, **11**, p. 2559: Wave lengths of the stronger lines in the helium spectrum.
- TSCHERMACK. *Pflugers Archiv.*, **88**, p. 95, 1901: Use of the helium spectrum as a standard for wave-length measurement.
- NUTTING, P. G., and TUGMAN, O. *Bull. Bur. Standards*, **7**, pp. 49-70, 1911; *Chem. Abs.*, **5**, p. 2362: The intensities of some hydrogen, argon, and helium lines in relation to current and pressure.
- COBLENTZ, W. W. *Elec. Wld.*, **59**, p. 365, 1912; *Chem. Abs.*, **6**, p. 1100: Special energy distribution of neon and helium.
- GERDIEN, H., and HOLEN, R. *Ann. Phys.*, **27**, pp. 844-853, 1908; *Chem. Abs.*, **3**, 1242: Spectrum of the canal rays in helium.
- LOHMANN, W. *Physik. Zeit.*, **9**, pp. 145-148, 1908; *Chem. Abs.*, **2**, p. 2041: The Zeeman effect of the helium lines.
- MOLYNEAUX, JANE. *Physik. Zeit.*, **13**, pp. 259-260, 1912; *Chem. Abs.*, **6**, 1566: Displacement of middle component of normal Zeeman triplet in the helium spectrum.
- PURVIS, J. E. *Proc. Camb. Phil. Soc.*, **15**, pp. 45-52, 1908; *Chem. Abs.*, **3**, p. 1364: The rotation of various spectral lines of neon, helium, and sodium in a magnetic field.
- RICHARDSON, O. W., and BAZZONI, C. B. *Phil. Mag.*, **34**, pp. 285-308, 1917; *Chem. Abs.*, **12**, p. 21: The limiting frequency in the spectra of helium, hydrogen, and mercury in the extreme ultra-violet.
- COLLIE. *Proc. Roy. Soc., Lond.*, **71**, p. 25, 1902: The influence of mercury vapor on the helium spectrum.
- WOOD, R. W., and FRANCK, J. *Physik. Zeit.*, **12**, pp. 81-83, 1911; *Phil. Mag. (6)*, **21**, pp. 265-270; *Chem. Abs.*, **5**, 1361: Change in resonance spectrum of iodine by the presence of helium.
- WOOD, R. W. *Physik. Zeit.*, **12**, pp. 1204-1211, 1912; *Chem. Abs.*, **6**, 1396: Resonance spectra of iodine vapor and their destruction by gases of the helium group.
- BIRGE, R. T. *Astrophys. J.*, **32**, 112-124, 1910; *Chem. Abs.*, **5**, p. 2593: Formulas for the spectral series for the alkali metals and helium.
- HICKS, W. M. *Trans. Roy. Soc., Lond. (A)*, **210**, pp. 57-111, 1910; *Chem. Abs.*, **4**, p. 2903: A critical study of the spectral series; alkalies, hydrogen, and helium.
- CURTIS, W. E. *Proc. Roy. Soc., Lond. (A)*, **89**, pp. 146-149, 1913; *Chem. Abs.*, **8**, p. 7: A new band spectrum associated with helium.
- GOLDSTEIN, E. F. *Physik. Zeit.*, **14**, pp. 624-629, 1913; *Chem. Abs.*, **7**, p. 3267: A new spectrum belonging to helium. Contains also a description of the apparatus and method of obtaining the helium used.
- KOCH, J. *Ann. physik.*, **48**, pp. 98-109, 1915; *Chem. Abs.*, **10**, p. 850: New line series in the helium spectrum.
- RIECKE. *Physik. Zeit.*, **16**, pp. 222-227, 1915; *Chem. Abs.*, **10**, 418: Bohr's theory of the series spectrum.
- FWLER, A. *Proc. Roy. Soc., Lond. (A)*, **91**, pp. 208-216, 1915; *Chem. Abs.*, **9**, p. 1426: New type of series in the band spectrum associated with helium.

- NICHOLSON, J. W. *Proc. Roy. Soc. (A)*, **91**, pp. 432-439, 1915; *Chem. Abs.*, **9**, 2482: Band spectrum associated with helium.
- RICHARDSON, O. W., and BAZZONI, C. B. *Nature*, **98**, p. 5, 1916; *Chem. Abs.*, **10**, p. 3024: Observations on the excitation of helium spectra.
- NICHOLSON, J. W. *Phil. Mag.*, **28**, pp. 90-103, 1914; *Chem. Abs.*, **8**, p. 3644: Atomic structure and the spectrum of helium.
- NICHOLSON, J. W. *Nature*, **94**, p. 642, 1915; *Chem. Abs.*, **9**, 1003: The spectra of hydrogen and helium.
- BOHR, M. *Nature*, **95**, pp. 6-7, 1915; *Chem. Abs.*, **9**, p. 1269: The spectra of hydrogen and helium.
- EVANS, E. J. *Phil. Mag.*, **29**, pp. 284-297, 1915: The spectra of hydrogen and helium.
- NICHOLSON, J. W. *Nature*, **95**, p. 33, 1915; *Chem. Abs.*, **9**, p. 1269: The spectra of hydrogen and helium.
- MERTON, T. R. *Nature*, **95**, p. 65, 1915; *Chem. Abs.*, **9**, p. 1269: The spectra of hydrogen and helium.
- MERTON, T. R., and NICHOLSON, J. W. *Proc. Roy. Soc. Lond. (A)*, **93**, pp. 27-28, 1916; *Chem. Abs.*, **11**, p. 555: Phenomena relating to the spectra of hydrogen and helium. A study of relative intensity distribution.
- STARK. *Electrische Spektralanalyse Chemischer Atome* (Book), 138 pp., Leipzig, S. Hirzel, 1914: The electrical spectrum-analysis of the chemical atom.
- FULCHER, G. S. *Astrophys. Jour.*, **41**, pp. 359-372, 1915: The Stark effect and atomic structure.
- SMITH, HAROLD. *Phil. Mag.*, **1**, **30**, pp. 805-811, 1915; *Chem. Abs.*, **10**, p. 422: Conductivity in mixtures of helium and hydrogen, and spectrum of the positive column.
- BRUNETTI, RITA. *Atti. Accad. Lincei*, **24**, I, pp. 719-723, 1915; *Chem. Abs.*, **9**, p. 2835: The Stark-LoSurdo phenomenon in the helium spectrum.
- STARK, J. *Ann. Physik.*, **51**, pp. 220-236, 1916; *Chem. Abs.*, **11**, p. 232: The carrier of the principal and secondary series of the alkalies, alkaline earths, and helium. Theoretical.
- ISHIWARA, J. *Proc. Tokyo Math. Phys. Soc. (2)*, **8**, pp. 540-550, 1916; *Chem. Abs.*, **11**, p. 3161: Structure of the atom core. Mathematical discussion of the spectra of hydrogen and helium.
- NYQUIST, H. *Proc. Nat. Acad. Sci.*, **3**, pp. 399-401, 1917; *Chem. Abs.*, **11**, p. 3160: The Stark effect in helium and neon.
- MERTON, T. R. *Proc. Roy. Soc., Lond. (A)*, **95**, pp. 30-38, 1918; *Chem. Abs.*, **12**, p. 2492: Electric resolution and broadening of the helium lines.
- TAKAMINE, I. T., and YOSHIDA, U. *Mem. Coll. Sci. Kyoto. Imp. Univ.*, **2**, pp. 325-334, 1918: The effect of an electric field on the spectrum lines of hydrogen and helium.
- TAKAMINE, I. T., and KOKUBU, N. *Proc. Tokyo Math. Phys. Soc. (2)*, **9**, pp. 394-404, 1918; *Chem. Abs.*, **12**, p. 2493: Studies on the Stark effect in helium and hydrogen.

3. OPTICAL PROPERTIES OF HELIUM

- RAYLEIGH. *Chem. News*, **72**, p. 223, 1895: Refractive index of helium.
- RAMSAY and TRAVERS. *Proc. Roy. Soc.*, **62**, p. 225, 1897: Refractive index of helium. The refractive index of a mixture of equal parts of helium and hydrogen is 3 per cent lower than would be calculated from the theory of mixtures.
- RAMSAY and TRAVERS, *Proc. Roy. Soc., Lond.*, **67**, p. 329, 1900: Refractive index of helium.
- SHEEL, K., and SCHMIDT, R. *Verh. deut. physik. Ges.*, **10**, 207-210, 1908; *Chem. Abs.*, **2**, p. 2324: The refractive index of helium.
- SHEEL, K., and SCHMIDT, R. *Physik. Zeit.*, **9**, pp. 921-923, 1908; *Chem. Abs.*, **3**, 744: The refractive index of helium.

- HERRMANN, K. *Verh. deut. Physik. Ges.*, **10**, pp. 211-216, 1908; *Chem. Abs.*, **2**, p. 2325: Refraction and dispersion of helium.
- HERRMANN, K. *Verh. deut. physik. Ges.*, **10**, pp. 476-482, 1908; *Chem. Abs.*, **2**, p. 3175: Refraction and dispersion of helium.
- BURTON, W. *Proc. Roy. Soc., Lond. (A)*, **80**, pp. 390-405, 1908; *Chem. Abs.*, **3**, p. 1116: The refractive index and dispersion of light in argon and helium.
- CUTHBERTSON, C. *Proc. Roy. Soc., Lond. (A)*, **81**, pp. 440-448, 1908; *Chem. Abs.*, **4**, p. 1935: The refraction and dispersion of krypton and xenon and their relation to those of helium and argon.
- CUTHBERTSON, C., and CUTHBERTSON, M. *Proc. Roy. Soc. Lond. (A)*, **84**, pp. 13-15, 1910; *Chem. Abs.*, **5**, p. 232: Refraction and dispersion of argon and dispersion of helium, neon, krypton, and xenon.
- CUTHBERTSON, C., and METCALFE, E. P. *Proc. Roy. Soc., Lond. (A)*, **80**, pp. 411-419, 1908; *Chem. Abs.*, **3**, p. 1117: The dispersion of gaseous mercury, sulphur, phosphorus, and helium.
- DAVISSON, C. *Phys. Rev.*, **8**, pp. 20-27, 1916; *Chem. Abs.*, **10**, p. 2068: The dispersion of hydrogen and helium according to Bohr's theory.
- STARK, J., and GIESEL, F. *Physik. Zeit.*, **8**, pp. 580-583, 1907; *Chem. Abs.*, **2**, p. 1234: Light omission of air and helium exposed to alpha-rays.

4. SOLUBILITY AND ABSORPTION OF HELIUM

- RAMSAY, COLLIE, and TRAVERS, J. *Chem. Soc.*, **67**, p. 684, 1895: Solubility of helium. Entirely insoluble in alcohol and benzene. One volume of water dissolves 0.0073 volume of helium at 18.2° C.
- ESTREICHER, TH. *Z. phys. Chem.*, **31**, p. 176, 1899: Solubility of helium in water at various temperatures.
- WINKLER, L. W. *Z. phys. Chem.*, **55**, p. 344, 1906: Solubility of helium; questions results of Estreicher.
- V. ANTROPOFF, A. *Proc. Roy. Soc., Lond. (A)*, **83**, pp. 474-483, 1910; *Chem. Abs.*, **4**, p. 2077: The solubility of xenon, krypton, neon, and helium in water.
- BERTHELOT. *Compt. rend.*, **124**, p. 113, 1897: Supposed chemical action of helium on benzene and carbon-disulphide vapors under the electric discharge.
- DEWAR. *Compt. rend.*, **139**, p. 261, 1904: Absorption of helium in wood charcoal.
- BRAUNER, B. *Chem. News*, **71**, p. 271, 1895: Absorption of helium in nickel electrodes.
- FRIEDLANDER, S. *Z. phys. Chem.*, **19**, p. 657, 1896: Absorption of helium in platinum electrodes of vacuum tubes.
- TRAVERS, W. M. *Proc. Roy. Soc., Lond.*, **60**, p. 449, 1896: Absorption of helium in platinum electrodes of vacuum tubes.
- STRUTT, R. J. *Proc. Roy. Soc., Lond. (A)*, **87**, pp. 381-384, 1912; *Chem. Abs.*, **7**, p. 722: Absorption of helium and other gases under the electric discharge.
- SIEVERTS, A., and BERGNER, E. *Ber.*, **45**, pp. 2576-2583, 1912; *Chem. Abs.*, **7**, p. 2142: Solubility of argon and helium in solid and liquid metals, and in quartz.
- KOHLSCHUTTER, V., and VOGT, K. *Ber.*, **38**, pp. 1419-1430, 2992-3002, 1905: Solid solutions of the inactive gases in uranium oxide.
- PIUTTI, A. *Nature*, **84**, pp. 543-544, 1910; *Chem. Abs.*, **5**, p. 626: Absorption of helium in salts and minerals.
- TROOST and OUVREARD. *Compt. rend.*, **121**, p. 394, 1895: Supposed compound of helium with magnesium.
- COOKE. *Proc. Roy. Soc., Lond. (A)*, **77**, p. 148, 1906; *Z. phys. Chem.*, **55**, p. 537, 1906: Further researches on the chemical behavior of helium.
- RAMSAY and COLLIE. *Chem. News*, **73**, p. 259, 1896: Unsuccessful attempts to form helium compounds.

5. DENSITY OF HELIUM

[See also following heading on "Pressure-volume relations."]

- LANGLET. *Compt. rend.*, **120**, p. 122, 1895; *Z. anorg. Chem.*, **10**, 289, 1895: Density of helium from cleveite.
- RAMSAY and TRAVERS. *Proc. Roy. Soc., Lond.*, **62**, p. 316, 1897; *Proc. Roy. Soc. Lond.*, **67**, 329, 1900: Good determinations of the density of helium. Ramsay's earlier determinations (not indexed) were in error.
- WATSON, H. E. *J. Chem. Soc.*, **97**, pp. 810-833, 1910; *Chem. Abs.*, **4**, p. 2076: Densities and molecular weights of neon and helium.
- HEUSE, W. *Ber. physik. Ges.*, **15**, pp. 518-523, 1913; *Chem. Abs.*, **7**, p. 3864: The density and atomic weight of helium. Finds molecular weight of 4.002.
- TAYLOR, T. S. *Phys. Rev.*, **10**, pp. 653-660, 1917; *Chem. Abs.*, **12**, p. 548: Determination of the density of helium by means of a quartz microbalance.
- GUYE, P. A. *J. Chim. Phys.*, **16**, pp. 46-61, 1918; *Chem. Abs.*, **12**, p. 2147: Improvements to be applied to methods of weighing. The elastic microbalance. Application to the atomic weights of helium and hydrogen.

6. PRESSURE-VOLUME RELATIONS FOR GASEOUS HELIUM

- KUENEN and RANDALL. *Chem. News*, **72**, p. 295; 1895: Pressure volume relations of helium between -210° and $+237^{\circ}$ C.
- OLSZEWSKI. *Ann. Phys. Wied. (2)*, **59**, p. 184; 1896.
- RAMSAY and TRAVERS. *Proc. Roy. Soc., Lond.*, **67**, p. 329; 1900: Isotherms of helium at 11.2° C and 100° C.
- TRAVERS and JAQUEROD. *Chem. News*, **86**, p. 61, 1902; *Z. Physik. Chem.*, **45**, p. 385, 1903: Coefficient of expansion of helium.
- TRAVERS and JAQUEROD. *Accad. Sci. Phys. Geneve (4)*, **14**, pp. 97-99; 1903: The coefficient of expansion of hydrogen and helium.
- TRAVERS and JAQUEROD. *Zeit. phys. Chem.*, **45**, pp. 456-460; 1903: The apparent value of the critical constants and boiling point of helium and an attempt to liquefy the gas.
- JAQUEROD and SCHEUER. *Compt. rend.*, **140**, p. 1384; 1905: Compressibility of helium.
- BURT, F. P. *Trans. Faraday Soc.*, **6**, pp. 19-26; 1906: The compressibility of helium and neon.
- PLANCK, I. M. *Sitz.-Ver. Akad. Berlin*, **32**, pp. 633-647, 1909; *Chem. Abs.*, **3**, p. 132: The canonical equation of state of monatomic gases. Equation "characterizes completely the thermodynamic properties of a substance."
- ONNES, H. K. *Proc. Acad. Amsterdam*, **10**, pp. 741-742, 1909; *Chem. Abs.*, **3**, p. 132: Isotherms of helium at -253° and -259° C.
- ONNES, H. K. *Proc. Acad. Amsterdam*, **10**, pp. 445-450, 1909; *Chem. Abs.*, **3**, p. 132: Isotherms of helium between 100° C and -217° C.
- ONNES, H. K. *Verslag K. Akad. Wet.*, **18**, pp. 168-172; *Chem. Abs.*, **5**, p. 838: Isotherms of neon and helium and their mixtures.
- ONNES, H. K. *Proc. Acad. Amsterdam*, **14**, pp. 678-684, 1913; *Chem. Abs.*, **7**, p. 2327: Isotherms of monatomic gases. Thermal properties of helium.
- ONNES, H. K. *Bull. assoc. intern. froid.*, **6**, pp. 103-134, 1916; *Chem. Abs.*, **10**, p. 1451: Brief survey of recent work of Leiden Cryogenic Laboratory containing, among other things, methods and results upon the maximum density of helium.
- HOLBORN, L., and SCHULTZE, H. *Ann. Physik.*, **47**, pp. 1089-1111, 1915; *Chem. Abs.*, **10**, p. 416: Isotherms of helium. Range 0° - 200° C up to about 100 atmospheres.
- HOLBORN and SCHULTZE. *Z. Electrochem.*, **21**, pp. 501-511; 1915: Work of the Reichsanstalt. Pressure-volume relations of helium. Same work probably given in greater detail in preceding reference.

VAN LAAR, J. J. Verslag. K. Akad. Wet., **24**, pp. 1635-1657, 1916; Chem. Abs., **10**, p. 2817: Data on the gas constants of the helium series.

7. DIFFUSION AND EFFUSION OF HELIUM

- SCHMIDT, R. Ann. phys. (4), **14**, pp. 801-821, 1904; also separate publication: The diffusion of helium and argon.
- LONIUS, A. Dissertation (Halle, 1909): The diffusion coefficient for argon-helium mixtures and its dependence upon the composition of the mixtures.
- RAMSAY and TRAVERS. Proc. Roy. Soc., Lond., **61**, p. 267; 1897: Diffusion of helium; it does not diffuse through red-hot palladium, platinum, or iron.
- JAQUEROD and PERROT. Compt. rend., **139**, p. 789; 1904: The diffusion of helium through hot quartz. Its use as a thermometric substance.
- JAQUEROD and PERROT. Arch. sci. phys. Nat. (4), **18**, pp. 613-615, 1904; Arch. sci. phys. Nat. (4), **20**, p. 128, 1905: The diffusion of helium through silica at high temperatures.
- DEWAR, J. Proc. Roy. Inst., **21**, pp. 813-826; J. Chem. Soc., **114**, II, pp. 186-187; Chem. Abs., **12**, p. 2275: Diffusion of gases through rubber.
- RAMSAY. Ann. Chim. Phys. (7), **13**, p. 433; 1898: Effusion of helium. Is 10 per cent greater relative to hydrogen than the difference in densities would indicate?
- DONNAN. Phil. Mag. (5), **49**, p. 423; 1900: Viscosity of helium; rate of effusion.

8. VISCOSITY OF HELIUM

[See also effusion under preceding heading.]

- RAYLEIGH. Proc. Roy. Soc., Lond., **59**, p. 198; 1895: Viscosity of helium.
- SCHULTZE, H. Ann. Physik. (4), **6**, pp. 302-314; 1901: The internal friction of helium and its alteration with temperature.
- TANZLER, P. Ber. Physik. Ges. (4), p. 222; 1906: The coefficient of internal friction of helium.
- SCHIERLOH. Dissertation (Halle; 1908): The coefficient of internal friction of argon and helium.
- ONNES, DORSMAN, and WEBER. Verslag. K. Akad. Wet., **21**, pp. 1375-1384, 1385-1391, 1530-1534; 1913: Proc. Acad. Amsterdam, **15**, 1386-1403; 1913; Leiden Comm. Physic. Lab., **134**, a, b, c: Investigation of the viscosity of gases at low temperatures.
- GILLE, A. Ann. Physik., **48**, pp. 799-837; 1915; Chem. Abs., **10**, p. 844: Viscosity coefficients of mixtures of hydrogen and helium.

9. SPECIFIC HEATS OF HELIUM

- LANGLET. Zeit. anorg. chem., **10**, p. 289; 1895: Ratio of specific heats of helium.
- RAMSAY, COLLIE, and TRAVERS. J. Chem. Soc., **67**, p. 684; 1895: Ratio of specific heats of helium.
- THOMAS. Dissertation (Marburg; 1905): Determination of the specific heat of helium. The atomic heat of helium and argon.
- BEHN, U., and GEIGER, H. Verh. deut. Physik. Ges., **9**, pp. 657-666; 1907; Chem. Abs., **2**, 1220: A modification of the Kundt method of determining the specific heat ratio and a new determination of this ratio for helium.
- EGGERT. Dissertation (Marburg; 1910): Determination of specific heat of helium at various temperatures and its significance in connection with the kinetic theory of monatomic gases.
- SCHUEL, K., and HEUSE, W. Sitz.-Ber. Akad. Berlin, **1913**, pp. 44-48; Chem. Abs., **7**, p. 2507. Specific heat of helium and of certain diatomic gases between 20° and 180°.

- EGGERT, A. *Ann. Physik*, **44**, pp. 643-656; 1914; *Chem. Abs.*, **8**, p. 2977: Determination of the specific heat of helium at ordinary and higher temperatures. No indication that specific heat changes with temperature.
- EUCKEN, A. *Verh. deut. physik. Ges.*, **18**, pp. 4-17; 1916; *Chem. Abs.*, **10**, p. 1129: Thermal behavior of some compressed and condensed gases at low temperatures. Specific heats of hydrogen (gas at several pressures and liquid), helium, argon (solid and liquid), nitrogen (liquid and two solid forms), oxygen (liquid and three solid forms), carbon monoxide (liquid and two solid forms), and carbon dioxide (solid at various temperatures). Heat of fusion, transformation, and evaporation of the various phases.
- ONNES, H. K. *Proc. Acad. Amsterdam*, **14**, pp. 678-684; 1911; *Chem. Abs.*, **7**, p. 2327: Thermal properties of helium.

10. THERMAL CONDUCTIVITY OF HELIUM

- SCHWARZE, W. *Physik. Zeit.*, **4**, p. 229; 1903: The heat conductivity of argon and helium.
- SCHWARZE, W. *Ann. Physik.* (4), **11**, pp. 303-330; 1903: Determination of the thermal conductivity of argon and helium by the method of Schiermacher.

VIII. LIQUEFACTION AND PROPERTIES OF LIQUID HELIUM

- OLSZEWSKI, K. *Ann. Phys. Wied.* (2), **59**, p. 184; 1896: Attempt to liquefy helium.
- DEWAR. *Proc. Chem. Soc.*, pp. 129 and 195, 1897-98: Attempt to liquefy helium.
- DEWAR. *Chem. News*, **84**, p. 49; 1901: Attempt to liquefy helium.
- DEWAR. *Proc. Roy. Soc., Lond.*, **68**, pp. 360-366; 1901: Experiments on the liquefaction of helium at the temperature of liquid hydrogen.
- DEWAR. *Compt. rend.*, **139**, pp. 421-422; 1904: Liquefaction of helium.
- TRAVERS and JAUQUEROD. *Z. phys. chem.*, **45**, pp. 456-460; 1903: Attempt to liquefy helium.
- OLSZEWSKI. *Z. komprim. Gase*, **9**, pp. 54-56, 1905; *Ann. Phys.* (4), **17**, p. 944, 1905; *Ann. Chim. Phys.* (8), **8**, pp. 139-144; 1906: Attempt to liquefy helium. Author believed he had reached a temperature of 1.7° absolute without success.
- ONNES, H. K. *Verslag. K. Akad. Wet.*, **16**, pp. 819-822, 1908; *Proc. Acad. Amsterdam*, **10**, p. 744; 1908. *Chem. Abs.*, **3**, 132: Experiments on the condensation of helium by expansion.
- ONNES, H. K. *Chem. Ztg.*, **32**, pp. 901-903, 1908; *Chem. Abs.*, **2**, p. 3317: The liquefaction of helium. Contains also some physical constants of the element.
- ONNES, H. K. *Verslag. K. Akad. Wet.*, **17**, pp. 163-179, 1908; *Proc. Acad. Amsterdam*, **11**, pp. 168-185, 1908; *Leiden Comm. Phys. Lab.*, No. 108, 1908; *Arch. neerl. Sci. Soc.* (2), **14**, pp. 289-308, 1909; *Chem. Abs.*, **4**, p. 550: The liquefaction of helium.
- ONNES, H. K. *Compt. rend.*, **147**, pp. 421-424; 1908: Liquid helium.
- ANONYMOUS. *Science* **28**, pp. 180, 316; 1908: Liquefaction of helium; reference to work of Onnes.
- ANONYMOUS. *Chem. News*, **98**, p. 37; 1908: Liquefaction of helium; reference to work of Onnes.
- LORENTZ, H. A. *Arch. neerland. Sci.* (2), **13**, p. 492, 1909; *Chem. Abs.*, **3**, p. 1848: Liquefaction of helium. The history and achievements of the Onnes laboratory in Leyden to the liquefaction of helium.
- ONNES, H. K. *Chem. Ztg.*, **34**, pp. 1373-1374, 1910; *Chem. Abs.*, **5**, p. 1010: Investigations carried out in the low-temperature laboratory at Leiden.

- ONNES, H. K. *Proc. Acad. Amsterdam*, **13**, pp. 1093-1113, 1911; *Chem. Abs.*, **6**, p. 6: Experiments with liquid helium. Liquid-helium bath, constant-volume helium thermometer, vapor density, vapor pressure, and density of liquid helium.
- ONNES, H. K. *Proc. Acad. Amsterdam*, **14**, pp. 204-210, 1911; *Chem. Abs.*, **7**, p. 2327: Experiments with liquid helium. A helium cryostat.
- ONNES, H. K., and WEBER, S. *Proc. Acad. Amsterdam*, **18**, pp. 493-507, 1915; *Chem. Abs.*, **10**, p. 308: Vapor pressure of helium. Temperature obtained with liquid helium. Discussion of low-temperature measurement.
- MEISSNER. *Zeit. Electrochem.*, **21**, pp. 501-511, 1915: Work of Reichsanstalt on the liquefaction of hydrogen and helium.

IX. APPLICATIONS OF HELIUM

1. APPLICATION OF HELIUM TO THERMOMETRY

- KUENEN and RANDALL. *Chem. News*, **72**, p. 295, 1895: Use of helium in low-temperature thermometers.
- OLZEWSKI. *Ann. Phys. Wied.* (2), **59**, p. 184, 1896: Use of helium in low-temperature thermometers.
- DEWAR. *Am. J. Sci.* (4), **11**, p. 291, 1901: Use of helium for low-temperature thermometers.
- TRAVERS, SENTER, and JAQUEROD. *Chem. News*, **86**, p. 61, 1902: Use of helium in low-temperature thermometers.
- ONNES, H. K. *Proc. Acad. Amsterdam*, **10**, pp. 589-591, 1908; *Chem. Abs.*, **3**, p. 132: Derivation of the pressure coefficient of helium for the international thermometer and the reduction of the readings of the helium thermometer to the absolute scale.
- ONNES, H. K., and HOLST, G. *Verslag. Akad. Wetenschappen.*, **23**, pp. 175-182; *Chem. Abs.*, **9**, p. 747: The measurement of very low temperatures. A comparison of the hydrogen, helium, and platinum resistance thermometers at temperatures down to the freezing point of hydrogen.
- HOLBORN, L., and HENNING, F. *Ann. Physik.*, **35**, pp. 761-764, 1911; *Chem. Abs.*, **5**, p. 3642: Comparison of the platinum, nitrogen, hydrogen, and helium thermometers and the determination of certain fixed points between 200 and 450°.
- CATH, P. G., ONNES, H. K., and BURGERS, J. M. *Proc. Acad. Sci. Amsterdam*, **20**, pp. 1163-1176, 1918; *Chem. Abs.*, **12**, p. 2267: Comparison of the platinum and gold resistance thermometers with the helium thermometer.
- JAQUEROD and PERROT. *Compt. rend.*, **139**, p. 789, 1904: Diffusion of helium through quartz at high temperatures makes it inapplicable for use in thermometers for measuring high temperatures.
- DORN, E. *Physik. Zeit.*, **7**, p. 312, 1906: Use of helium in a platinum-iridium vessel to measure high temperatures.
- CARIO. *Dissertation* (Halle, 1907): Use of helium in platinum-iridium vessels at high temperatures.

2. APPLICATIONS OF LIQUID HELIUM ESPECIALLY TO DETERMINATION OF ELECTRICAL PROPERTIES OF METALS AT LOW TEMPERATURES

[See also heading on "Liquefaction and properties of liquid helium".]

ONNES, H. K., is the author of all articles under this heading unless otherwise noted. Leiden, Van Bemmelen Gedenkboek, pp. 441-446; *Chem. Abs.*, **5**, p. 3186:

The attainment of temperatures considerably below the boiling point of helium. *Electrician*, **67**, p. 657, 1911; *Chem. Abs.*, **5**, p. 3541: Electrical resistance of pure metals at liquid helium temperatures.

- Proc. Acad. Amsterdam, **13**, pp. 1274-1276, 1911; Chem. Abs., **6**, p. 6: Resistance of pure mercury at liquid helium temperatures.
- Proc. Acad. Amsterdam, **14**, pp. 113-115, 1911; Chem. Abs., **6**, p. 6; **7**, p. 2327: The electrical resistance of pure metals. The sudden change in the rate at which the resistance of mercury disappears.
- Electrician, **71**, pp. 855-857, Chem. Abs., **7**, p. 3924, 1913: Electrical resistance of pure metals at liquid helium temperatures.
- Verslag. K. Akad. Wetenschappen, **1913**, pp. 1284-1305, 1388-1391; Chem. Abs., **8**, p. 1907, 1914: The potential difference necessary for the flow of an electric current through mercury below 4.19° absolute.
- Verslag. K. Akad. Wet., **22**, pp. 1413-1421; **23**, pp. 167-172, 1914; Chem. Abs., **9**, p. 545: Imitating a permanent magnet by means of superconductors.
- Comp. rend., **159**, pp. 34-38, 1914; Chem. Abs., **8**, p. 3264: The persistence of electric currents without electromotive force in the superconductors.
- Proc. Acad. Amsterdam, **16**, pp. 673-688, 1914; Chem. Abs., **8**, p. 2294: The sudden disappearance of the ordinary resistance of tin and the superconductive state of lead.
- Proc. Acad. Amsterdam, **16**, pp. 987-992, 1914; Chem. Abs., **9**, p. 735: Hall effect and the magnetic change in resistance at low temperature. The appearance of galvanic resistance in supraconductors which are brought into a magnetic field, at the threshold value of the field.
- Verslag. K. Akad. Wetenschappen, **22**, pp. 1027-1033; Chem. Abs., **8**, p. 2107: Hall effect and the change of resistance in a magnetic field at low temperatures.
- Verslag. K. Akad. Wetenschappen, **23**, pp. 172-175, 1914; Chem. Abs., **9**, p. 545: Phenomena of incipient paramagnetic saturation.
- Verslag. K. Akad. Wetenschappen, **23**, pp. 493-501, 1914: Hall effect and the change of resistance in magnetic fields.
- Verslag. K. Akad. Wetenschappen, **23**, pp. 703-710, 1914; Chem. Abs., **9**, p. 1580: Specific heat and thermal conductivity of mercury and some measurements of the conductivity and thermoelectromotive force at liquid-helium temperatures.
- ONNES, DORSMAN, and WEBER. Verslag. K. Akad. Wetenschappen, **21**, pp. 1375-1384, 1385-1391, 1530-1534, 1913; Proc. Acad. Amsterdam **15**, pp. 1386-1403, 1913; Leiden Comm. Phys. Lab., **134**, a, b, c.: Investigation of the viscosity of gases at low temperatures.
- Bull. Assoc. Intern. Froid., **6**, pp. 103-134, 1915; Chem. Abs., **10**, p. 1451: Report on researches made in the Leiden Cryogenic Laboratory between the second and third congresses of refrigeration. A review.

3. APPLICATIONS OF HELIUM TO PHOTOMETRY, ETC.

- TSCHERMAK, A. Pflugers, Archiv., **88**, p. 95, 1901: Use of the helium spectrum as a standard for wave-length measurement.
- NUTTING, P. G. Bull. Bur. Stds., **4**, pp. 511-523, 1908; Chem. Abs., **2**, p. 2895: The helium tube as a primary light standard.
- NUTTING, P. G. J. Wash. Acad. Sci., **1**, pp. 221-223, 1911; Chem. Abs., **6**, p. 543; Elec. Rev. West Elec., **59**, p. 1074: Helium tubes as light standards.
- HIRSHBERG, L. K. J. Gas. Ltg., **118**, p. 720, 1912; Chem. Abs., **6**, p. 3002: Helium as a unit of candlepower.
- DORN, E. Ann. Phys. (4), **16**, p. 784, 1904: Suggested application of helium-filled Plücker tube for the recognition of rapid electrical fluctuations.
- ZEHNDER, L. Physik. Zeit., **13**, pp. 446-449, 1912: Use of vacuum tubes containing helium to demonstrate properties of electric waves.

X. MISCELLANEOUS

- RAMSAY, COLLIE, and TRAVERS. *Compt. rend.*, **123**, pp. 214, 542, 1896; *Proc. Roy. Soc. Lond.*, **60**, p. 206, 1896; *Proc. Roy. Soc. Lond.*, **62**, p. 316, 1898: Attempt to separate helium into 2 or more components.
- RAMSAY, WM. *Rend. soc. chim. ital.* (2), **5**, pp. 137-150, 1907; *Chem. Abs.*, **7**, p. 3712: The rôle of helium in nature.
- SCHAUM, K. *Sitz.-Ber. Ges. Natw.*, pp. 43-44, 1904: The condition of helium in the sun.
- KEESOM, W. H. *Handl. Ned. Nat. Geneesk. Congres*, **11**, pp. 169-174, 1907; *Leiden Comm. Phys. Lab. Suppl.* 18 to 97-108, pp. 9-16, 1908: The properties of helium mixtures.
- COOKE, W. T. *Proc. Roy. Soc. Lond. (A)*, **77**, pp. 148-155, 1906; *Z. phys. Chem.*, **55**, pp. 537-546, 1906: Experiments on the chemical behavior of argon and helium. Vapor densities of various elements in these gases at 1,200°-1,300°.
- FORCRAND. *Compt. rend.*, **156**, pp. 1648-1651, 1913: The molecular heat of vaporization of substances boiling at low temperatures.
- HERTZ, G. *Ber. physik. Ges.*, **19**, pp. 268-288, 1917; *J. Chem. Soc.*, **114**, II, pp. 105-106, 1918; *Chem. Abs.*, **12**, p. 1723: Exchange of energy in the collisions between slowly moving electrons and molecules of gases. Calculated for helium and hydrogen which differ by a factor of 200.
- JEANS. *Phil. Mag.* (6), **8**, p. 692, 1904: The diameter of a helium molecule.
- ERFLE, H. *Ver. deut. physik. Ges.*, **10**, pp. 331-338, 1908; *Chem. Abs.*, **2**, p. 2493: The number of quasi-bound electrons in the helium atom.
- LORING, F. H. *Chem. News*, **106**, p. 37, 1912; *Chem. Abs.*, **6**, p. 3050: Is helium fundamentally an element of electropositive make-up?
- WILDE, H. *Chem. News*, **108**, p. 25, 1913; *Chem. Abs.*, **7**, p. 3432: Some new relations of atomic weights and transformation of neon and helium.
- HARKINS, W. D., and WILSON, E. D. *J. Am. Chem. Soc.*, **37**, pp. 1383-1396, 1915; *Chem. Abs.*, **9**, p. 2335: Structure of complex atoms; the hydrogen-helium system. Accounts for composition of 26 elements.
- SOMMERFIELD, A. *Ann. Physik.*, **53**, pp. 497-550, 1918; *Chem. Abs.*, **12**, p. 2159: The probable constitution of the helium atom (included in a theoretical paper of different title).
- KUNZ, J. *Phys. Rev.*, **12**, pp. 59-69, 1918; *Chem. Abs.*, **12**, p. 2160: Bohr's atom and magnetism. Theoretical, based on behavior of hydrogen and helium.
- DEWAR, J. *Engineering*, **87**, pp. 825-826, 1909; *Chem. Abs.*, **4**, p. 5: Problems connected with helium. Principally the use of helium for producing low temperatures.
- DEWAR, J. *Rev. Sci.*, **49**, pp. 450-457, 1911: Experiments with helium at low temperatures and low pressures.
- EDITORIAL. *Engineering*, **99**, pp. 144-145, 1915; *Chem. Abs.*, **9**, p. 1269: Hydrogen and the rare gases. Review of lecture by J. Dewar.
- RAMSAY, W., and RUDEF, G. *Die Edelgase* (the noble gases) (Book), Vol. II of Ostwald and Drucker's "Handbuch der allgemeinen chemie," Leipzig Akad Verlagsgesellschaft; *Chem. Abs.*, **12**, pp. 2482; 1918.
- RAMSAY, W. *Die Edlen and die Radioactiven Gase* (the noble and the radioactive gases) (Book), Leipzig Akad Verlagsgesellschaft; *Chem. Abs.*, **3**, p. 747.
- MOORE, R. B. *J. Franklin Inst.*, **186**, pp. 29-55, 1918; *Chem. Abs.*, **12**, p. 1607: Sir Wm. Ramsay. An account of his contributions to chemistry and a bibliography of his papers.

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